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Plain bearings — Symbols —

Part 2:
Applications

Paliers lisses — Symboles —

Partie 2: Applications

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 7904-2 was prepared by Technical Committee ISO/TC 123, *Plain bearings*.

ISO 7904 consists of the following parts, under the general title *Plain bearings — Symbols*:

— *Part 1: Basic symbols*

— *Part 2: Applications*

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Plain bearings — Symbols —

Part 2:
Applications

1 Scope

This part of ISO 7904 specifies practical applications of the general symbols laid down in ISO 7904-1 with regard to the calculations, design and testing of plain bearings.

ISO 7904-1 distinguishes between basic characters and additional signs. Additional signs are subscripts and superscripts. The symbols necessary for plain bearing calculations, design, manufacture and testing are combinations of the above-mentioned signs.

The symbols which have been found necessary for the calculations, design and testing of plain bearings are given in 3.1 and 3.2. They have been combined according to the recommendations given in ISO 7904-1. The list may be enlarged, if necessary.

Angles and directions of rotation are defined positively as rotating left-hand (counter-clockwise); the same applies to rotational frequencies, peripheral and angular velocities.

2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this part of ISO 7904. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this part of ISO 7904 are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 7904-1:1994, *Plain bearings — Symbols — Part 1: Basic symbols.*

3 Symbols and terms

3.1 Symbols (Roman alphabet)

A	heat-emitting surface (bearing housing); elongation at fracture
A_{lan}	land area
A_{lan}^{*}	relative land area
A_{P}	oil pocket area
A_{S}	area of cross-section
a	distance; acceleration; thermal diffusivity
a_F	distance between entrance of the gap and the location of the pivot point
a_F^{*}	relative distance between entrance of the gap and the location of the pivot point
a_M	off-set of bearing support
B	(breadth); nominal bearing width; effective bearing width at right angles to the direction of motion; diameter of a circular tilting pad
B^{*}	relative width; width ratio

B_H external width of bearing housing in axial direction

B_{tot} total bearing width at right angles to the direction of motion

b_{ax} width of axial outlet

b_c width of circumferential outlet

b_G width of oil groove; width of bleed groove

b_P width of oil pocket

C nominal clearance; concentration; chamfer

C^* relative bearing clearance (also ψ)

C_B difference between lobe or pad bore radius and shaft radius of a multi-lobed and tilting pad journal bearing

C_D bearing clearance; bearing diametral clearance (difference between journal bearing bore and shaft diameter)

$\overline{C}_D$ mean value of C_D

$C_{D,eff}$ effective bearing diametral clearance

$C_{D,max}$ maximum value of C_D

$C_{D,min}$ minimum value of C_D

C_{man} clearance range due to machining tolerances of a multi-lobed journal bearing

C_{max} maximum clearance of multi-lobed bearing

C_{min} minimum clearance of multi-lobed bearing

C_R bearing radial clearance (difference between journal bearing radius and shaft radius)

$\overline{C}_R$ mean value of C_R

$C_{R,eff}$ effective bearing radial clearance

$C_{R,max}$ maximum value of C_R

$C_{R,min}$ minimum value of C_R

C_{wed} wedge depth of a multi-taper land bearing ("thrust bearing clearance")

c specific heat capacity; stiffness coefficient

c_J flexural stiffness of shaft

c_p specific heat capacity (with p constant)

D nominal bearing diameter (inside diameter of journal bearing; mean diameter of thrust-bearing carrier ring)

D_B twice the radius of lobe or pad in a multi-lobed and tilting pad journal bearing

$D_{B,max}$ maximum value of D_B

$D_{B,min}$ minimum value of D_B

D_H diameter of bearing housing

D_i inside diameter of thrust-bearing carrier ring

D_J shaft diameter

$D_{J,max}$ maximum value of D_J

$D_{J,min}$ minimum value of D_J

D_o outside diameter of thrust-bearing carrier ring

d diameter; damping coefficient

d_{cp} diameter of capillaries

d_L oil hole diameter

E modulus of elasticity

E^* parameter of elasticity

E_B modulus of elasticity of bearing material

E_J modulus of elasticity of rotor material (sliding surface)

E_{rsl} resultant modulus of elasticity

e eccentricity (eccentricity between the axis of the shaft and the bearing axis)

e^* relative eccentricity (also ε)

e_B eccentricity of sliding surfaces (segments) of a multi-lobed and tilting pad journal bearing

e_F eccentricity of shaft in direction of load of a multi-lobed journal bearing

F bearing force (nominal load)

F^* bearing force parameter

F_E bearing force (with EHD influence)

F_E^* bearing force parameter (with EHD influence)

$F_{E,tr}$ bearing force (with EHD influence) at the limit of boundary lubrication

$F^*_{E,tr}$ bearing force parameter (with EHD influence) at the limit of boundary lubrication

F^*_{eff} effective bearing force parameter

F_f friction force

F^*_f friction force parameter

F_n normal force; normal to sliding surface

F_{rot} proportion of bearing force absorbed by the rotation of the rotor (wedge action)

F_{sc} static load

F_{sq} proportion of bearing force absorbed by displacement due to squeezing (squeeze action)

F_{st} bearing force at start ($N \approx 0$)

F_{stp} bearing force at stop ($N \approx 0$)

F_{tr} bearing force (without EHD influence) at the limit of boundary lubrication

F^*_{tr} bearing force parameter (without EHD influence) at the limit of boundary lubrication

f coefficient of friction; function

f^* friction parameter

f_h fluid friction coefficient (in the area of boundary lubrication)

f_{min} coefficient of friction on minimum of Stribeck curve

f_s coefficient of friction of a solid

f_{tr} coefficient of friction at transition to boundary lubrication

G shear modulus

g acceleration due to gravity

H nominal height

H_H height of bearing housing

HB Brinell hardness

HRB Rockwell hardness (ball)

HRC Rockwell hardness (cone)

HV Vickers hardness

h local lubricant film thickness (film thickness)

h^* relative local lubricant film thickness (relative film thickness)

h_{en} lubricant film thickness at entrance

h_{ex} lubricant film thickness at exit

h_G depth of oil groove

h_{lim} minimum permissible lubricant film thickness during operation

h^*_{lim} minimum permissible relative lubricant film thickness during operation

$h_{lim,tr}$ minimum permissible lubricant film thickness at transition to boundary lubrication

$h^*_{lim,tr}$ minimum permissible relative lubrication film thickness at transition to boundary lubrication

h_{min} minimum lubricant film thickness (minimum film thickness)

h^*_{min} relative minimum lubricant film thickness (relative minimum film thickness)

$h_{min,tr}$ minimum lubricant film thickness at transition to boundary lubrication

$h^*_{min,tr}$ relative minimum lubricant film thickness at transition to boundary lubrication

h_P depth of oil pocket

h_{wav} waviness of sliding surface

$h_{wav,eff}$ effective waviness of sliding surface

$h_{wav,eff,lim}$ maximum permissible effective waviness of sliding surface

h_0 local lubricant film thickness with $\varepsilon = 0$

h^*_0 relative local lubricant film thickness with $\varepsilon = 0$

$h_{0,max}$ maximum lubricant film thickness with $\varepsilon = 0$

$h^*_{0,max}$ lubricant film thickness ratio (relative maximum lubricant film thickness with $\varepsilon = 0$)

K_w coefficient of wear

k heat transmission coefficient

k^* heat transmission parameter

k_A outer heat transmission coefficient (reference area A)

k_i inner heat transmission coefficient (oil film)

L nominal length; length of sliding surface in direction of motion; length of pad in circumferential direction

L_H length of bearing housing at right angles to the axis

l_{ax} axial land length

l_c circumferential land length

l_{cp} length of capillaries

l_G length of oil groove

l_P length of oil pocket

l_{wed} length of wedge

M moment; mixing factor

M_F loading moment

M_f friction moment

m mass

N rotational frequency (revolutions per time unit)

N^* rotational frequency parameter

N_B rotational frequency of the bearing

N_{cr} critical rotational frequency of the rigidly supported shaft

N_F rotational frequency of the bearing force

N_J rotational frequency of the shaft

$N_{lim,tr}$ maximum permissible transition rotational frequency

N_{min} rotational frequency at minimum of friction of Stribeck curve

N_{rsn} resonance rotational frequency of the shaft assembled in a plain bearing

N_{tr} transition rotational frequency

P_{cl} cooling capacity; additional cooling

P_f frictional power

P_p pumping power

P_{th} heat flow rate

$P_{th,amb}$ heat flow rate to the ambient

$P_{th,f}$ heat flow rate based on frictional power

$P_{th,L}$ heat flow rate in the lubricant

P_{tot} total power ($P_p + P_f$)

P_{tot}^* total power parameter

p local lubricant film pressure, e.g. specific load

$\bar{p}$ specific load, e.g. load per unit of projected area

$\bar{p}_{dyn}$ dynamic specific load

p_{en} lubricant feed pressure

p_{en}^* lubricant feed pressure parameter

p_{lim} maximum permissible lubricant film pressure

$\bar{p}_{lim}$ maximum permissible specific bearing load

p_{max} maximum lubricant film pressure

p_{max}^* maximum lubricant film pressure parameter

p_P lubricant pressure in pockets

$\bar{p}_{sc}$ static specific load

$\bar{p}_{st}$ specific load at start ($N \approx 0$)

$\bar{p}_{stp}$ specific load at stop ($N \approx 0$)

Q lubricant flow rate; volume flow rate

Q^* lubricant flow rate parameter

Q_{cl} cooling oil flow rate

Q_p lubricant flow rate based on feed pressure

Q_p^* lubricant flow rate parameter based on feed pressure

Q_0 reference lubricant flow rate

Q_1 lubricant flow rate at the inlet to lubrication clearance gap (circumferential direction)

Q_1^* lubricant flow rate parameter at the inlet to lubrication clearance gap (circumferential direction)

Q_2 lubricant flow rate at the outlet of lubrication clearance gap (circumferential direction)

Q_2^* lubricant flow rate parameter at the outlet of lubrication clearance gap (circumferential direction)

Q_3 lubricant flow rate due to hydrodynamic pressure development

Q_3^* lubricant flow rate parameter due to hydrodynamic pressure development

R bearing inside radius of journal bearing

R_a mean value of surface finish C.L.A.

$R_{a,B}$ mean value of surface finish C.L.A. of bearing sliding surface

$R_{a,J}$ mean value of surface finish C.L.A. of shaft mating surface

R_B lobe or pad radius of a multi-lobed journal bearing and tilting pad journal bearing

R_{cp} flow resistance of capillaries (hydrostatic bearing)

R_J shaft radius

$R_{lan,ax}$ flow resistance of one land in axial direction (hydrostatic bearing)

$R_{lan,c}$ flow resistance of one land in circumferential direction (hydrostatic bearing)

R_P flow resistance of one pocket (hydrostatic bearing)

R_z average peak-to-valley height

$R_{z,B}$ average peak-to-valley height of bearing sliding surface

$R_{z,J}$ average peak-to-valley height of shaft mating surface

Re Reynolds number

Re_{cr} critical Reynolds number

r repeatability

S_F security against boundary lubrication due to excessive loading

S_N security against boundary lubrication due to lower frequency of rotation

So Sommerfeld number

So_{rot} Sommerfeld number (rotation)

So_{sq} Sommerfeld number (displacement due to squeezing)

So_{tr} Sommerfeld number at transition to boundary lubrication

s wall thickness

$s_{A,rsn}$ displacement amplitude of rotor vibration at resonance

T temperature

T_{amb} ambient temperature

T_B bearing temperature

T_{eff} effective temperature of the lubricant

T_{en} lubricant temperature at bearing entrance

T_{ex} lubricant temperature at bearing exit

T_g glass temperature (plastic testing)

T_J shaft temperature

T_L lubricant temperature

T_{lim} maximum permissible bearing temperature

T_1 lubricant temperature in pockets

T_2 lubricant temperature at the exit of the bearing clearance gap

t time

U peripheral speed; sliding velocity (related to the journal bearing shaft diameter or the mean thrust bearing carrier ring)

U_B peripheral speed of bearing

U_J peripheral speed of shaft

$U_{lim,tr}$ maximum permissible transition peripheral speed

$\overline{U}_R$ average velocity of flow at pre-restrictor of hydrostatic bearing

U_{tr} transition peripheral speed

u velocity component in x-direction; deformation in x-direction; uncertainty of measurement

V volume; surface velocity in y-direction; displacement velocity

VG viscosity grade

VI viscosity index

v velocity component in y-direction; deformation in y-direction

W surface velocity in z-direction; work (energy)

w velocity component in z-direction; deformation in z-direction

w_{amb} velocity of air surrounding the bearing housing

x coordinate parallel to the sliding surface, in circumferential direction

y coordinate normal to the sliding surface

Z number of sliding surfaces (pads) or pockets per bearing; necking after fracture

z coordinate parallel to the sliding surface, normal to circumferential direction (for journal bearings in axial direction, for thrust bearings normal to the shaft axis)

3.2 Symbols (Greek alphabet)

α heat transfer coefficient

α_l linear heat expansion coefficient

$\alpha_{l,B}$ linear heat expansion coefficient of the bearing

$\alpha_{l,J}$ linear heat expansion coefficient of the shaft

α_V cubic heat expansion coefficient

β attitude angle (angular position of shaft eccentricity related to the direction of load); temperature viscosity exponent

$\beta_{h,min}$ angle between direction of load and position of minimum lubricant film thickness

γ angular position of bearing load (bearing load in vertical direction: $\gamma = 0$)

Δ difference; Laplace operator

δ angular position of smallest lubrication clearance gap

δ_B angle of misalignment of the bearing (angular deviation of bearing)

δ_J angle of misalignment of the shaft (angular deviation of the shaft)

ε relative eccentricity (also e^*), relative elongation

ζ hydraulic resistance coefficient

η dynamic viscosity of the lubricant

$\bar{\eta}$ mean dynamic viscosity of the lubricant at clearance gap

η_{eff} effective dynamic viscosity of the lubricant

κ resistance ratio

λ thermal conductivity

μ relative stiffness of the bearing

ν kinematic viscosity of lubricant; Poisson's ratio

ν_B Poisson's ratio (bearing)

ν_J Poisson's ratio (shaft)

ξ restrictor ratio (hydrostatic bearing)

Π product; parameter

π Ludolf's number (π = 3,141592 ...)

ρ density

σ normal stress; standard deviation

τ shearing stress

Φ sliding surface utilization factor

φ angular coordinate in circumferential direction

ψ relative bearing clearance (also C^*)

$\bar{\psi}$ mean relative bearing clearance

ψ_{eff} effective relative bearing clearance

ψ_{man} relative manufacturing clearance of multi-lobed journal bearing

ψ_{max} maximum value of ψ

ψ_{min} minimum value of ψ

ψ_{20} relative bearing clearance at 20 °C (journal bearing)

Ω angular span of bearing sliding surface (segment)

ω angular velocity ($\omega = 2 \cdot \pi \cdot N$)

ω_B angular velocity of bearing

ω_h angular velocity (hydrodynamic)

ω_J angular velocity of shaft

ω_{rel} relative angular velocity

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